

Docket No.: 059516-0052



PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of : Customer Number: 20277
Zi-kui LIU, et al. : Confirmation Number: 1022
Application No.: 10/784,899 : Group Art Unit: 1762
Filed: February 24, 2004 : Examiner: Brian K. Talbot
For: BORIDE THIN FILMS ON SILICON

DECLARATION UNDER 37 C.F.R. § 1.132

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

1. I, Zi-Kui Liu, a co-inventor to the above-captioned application, hereby declare and say as follows:

2. I have read and am familiar with the disclosure and presently pending claims of the above-captioned application as well as issues raised in the Office Action mailed by the U.S. Patent & Trademark Office on September 2, 2005.

3. In the Office Action, certain claims were rejected under 35 U.S.C. § 103(a) as being unpatentable over Zeng et al., "*In situ* epitaxial MgB₂ thin films for superconducting electronics", Nature Materials, vol. 1, 2002, pp1-4 (hereinafter "Zeng"), in combination with Blank et al., "Superconducting Mg-B films by pulsed-laser deposition in an *in situ* two-step process using multicomponent targets", Appl. Phys. Lett., vol. 79, 2001, pp 394-396 (hereinafter "Blank") or T. He, R. J. Cava and J. M. Rowell, "Reactivity of MgB₂ with common substrate and electronic materials", Appl.

Phys. Lett., vol. 80, 2002, pp 291-293(hereinafter "He"). The Examiner's attention is directed to the fact that I am a co-author of the Zeng publication and familiar with the processing conditions disclosed therein.

4. In the Office Action at page 3, the Examiner admitted that Zeng fails to teach the use of a substrate consisting essentially of silicon, but nevertheless, asserted that either Blank or He teaches a variety of substrates for electronic application including Si, SiC Al₂O₃ and SrTiO₃ (STO). The Examiner concluded that substituting one known substrate for another would have been obvious to one of ordinary skill in the art, with the expectation of achieving similar results. Moreover, at page 4 of the Office action, the Examiner asserted that claims 9, 13-15 and 17 recite the step of maintaining the pressure of the vapor within the specified processing parameters of the recited equation, but the Examiner considered that the pressure of the vapor is a "result effective" variable that is optimized by one skilled in the art through routine experimentation. I respectfully disagree with the Examiner's conclusions. As explained in further detail below, I submit that the deposition of a MgB₂ thin film on a substrate consisting essentially of silicon would not occur with the processing conditions described by Zeng.

5. As disclosed in the Background section of the present application a problem existed in the art with the deposition of MgB₂ thin films on silicon. Specifically, a problem encountered in depositing MgB₂ is that sufficient magnesium vapor pressure is necessary to provide for a thermodynamically stable MgB₂ phase at elevated temperatures. This problem is complicated when forming boride thin films on substrates containing silicon because of magnesium's propensity to chemically react with silicon at high temperatures. Indeed, previous thermodynamic calculations and investigations

indicated that it was not possible to grow magnesium diboride thin films on a silicon substrate.

6. As described on page 6, lines 9-15 of the present specification, previous thermodynamic calculations and experimental investigations indicated that it was not possible to grow a magnesium diboride film on a silicon substrate due to the reaction between magnesium vapor and silicon. The understanding at the inability to grow a magnesium diboride film is evident in the He publication cited by the Examiner. The He publication is discussed in the present specification at page 2, lines 12-22. Magnesium's reactivity with silicon and silicon oxides leads to magnesium-silicon and magnesium-silicon-oxide compounds that contaminate the silicon surface and, in extreme situations, prevents usable magnesium boride films on silicon substrates. However, with the present invention, new and more detailed calculations have found the existence of a processing window in which thin films of magnesium boride on silicon substrates can be fabricated. The present invention's calculations show that magnesium boride films can be formed on a substrate consisting essentially of silicon, if the vapor pressure of the magnesium is lowered as compared to the processing pressures of He.

7. Moreover, as described in the detailed description of the present specification, at page 6, line 27 through page 7, line 8, the upper and lower limits in which magnesium vapor can be stably in contact with silicon can be calculated using the equation of the presently claimed subject matter. As shown in FIG. 1, the upper line in the region "gas+Si" can be approximated by $\text{Log}(P) = -9549.5/T + 9.1$; and the lower line can be approximated by the equation $\text{Log}(P) = -10142/T + 8.562$, where P represents pressure in units of Torr and T represents temperature in Kelvin (K). Maintaining

magnesium vapor pressure at a magnesium partial pressure in a reaction chamber within about the range defined by the above equations, permits magnesium vapor to interact and react with the boron precursor and minimizes, if not completely eliminates, any reaction between magnesium and silicon. By this process, a magnesium boride film can be formed directly on silicon without substantial amounts of magnesium-silicon contaminants between the substrate surface and the magnesium boride film.

8. In contrast, Zeng's disclosed methodology is directed to a hybrid physical-chemical vapor deposition of a magnesium diboride (MgB_2) thin film on SiC. Zeng fails to disclose or remotely suggest the above described processing window of the presently claimed subject matter. Indeed, Zeng discloses that a very high magnesium vapor pressure is required in order to keep the MgB_2 phase thermodynamically stable at elevated temperatures. Moreover, Zeng explains that because of the relatively high gas pressure and the flow pattern of the carrier gas in the reactor, the vapor from the heated pure Mg results in a high Mg vapor pressure near the substrate.

9. Therefore, the Examiner's proposed combination of using a substrate consisting essentially of silicon by the method of Zeng would result in the reaction of magnesium with silicon and silicon oxides and would lead to undesirable magnesium-silicon and magnesium-silicon-oxide compounds that contaminate the silicon surface. However, as described in the present specification, the magnesium boride film is substantially free of magnesium-silicon contaminates between the surface consisting essentially of silicon and the magnesium boride film. Further, contrary to the Examiner's assertion, none of the applied references provide any teaching or suggestion that the claimed vapor pressure can vary from the disclosed values and the prior art does not

provide one having ordinary skill in the art a reason to vary the vapor pressure in one direction or another to produce an expected desirable result. To the best of my knowledge, as of the filing date of the above-captioned application, no prior art reference described or suggested the presently claimed methodology for forming a thin film of magnesium boride on a substrate surface that consists essentially of silicon.

10. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code and that such willful statement may jeopardize the validity of the application or any patent issued thereon.



Zi-Kui Liu

12/21/2005
Date